CSCI 3753: Operating Systems

Week 7
October 10th, 2025

University of Colorado Boulder

Announcements

- PS2 due Sunday at midnight!
- Quiz 7 due today at midnight
- Midterm is next week!
- As always recitation materials are stored here

On-Going

- PA4
  - Create a shared array
- PA5
  - Create a DNS resolver
- PA6
  - Combine these to create a multi-threaded DNS resolver

Bounded Buffer Problem!!

Machine Components, Bootloader, Kernel Mode and System Calls (Chapter 2)

- What are the roles of BIOS/UEFI, boot loader, and kernel in the startup sequence?
- Why do we need kernel mode vs user mode? What would happen if there were only one mode?
- How does a system call differ from a regular function call?
- Can you give examples of system calls in Unix/Linux?
- What is the purpose of the trap table?

Loadable Kernel Modules, Bus Controllers, DMA, Device Drivers (Chapters 11+12)

- Why do we use LKMs instead of compiling everything directly into the kernel?
- What is the difference between kernel-space and user-space drivers?
- How does DMA improve I/O performance?
- What are interrupts and how do they relate to device drivers?
- What happens when a device driver misbehaves?

Processes and Interprocess Communication (Chapter 3)

- What are the main components of a process (address space, registers, PCB, etc.)?
- How does process creation work (fork/exec model in Unix)?
- What are the main IPC mechanisms (pipes, message queues, shared memory, sockets)?
- Why do we need synchronization when using shared memory?
- How is a process different from a program?

Threads, Thread Safety and Reentrant Code (Chapter 4)

- How do threads differ from processes?
- Why is shared memory both an advantage and a danger in threads?
- What makes a function thread-safe?
- What does “reentrant” mean, and are reentrant functions always thread-safe?
- Why do many OS-level services (like signal handling or printf) need to consider thread safety?

Synchronization (Chapters 6+7)

- What is a race condition? Can you describe one example?
- What are the three requirements for a critical section solution (mutual exclusion, progress, bounded waiting)?
- Why are busy-waiting and spinlocks inefficient? When might they still be used?
- How do hardware-level atomic instructions (test-and-set, compare-and-swap) help?

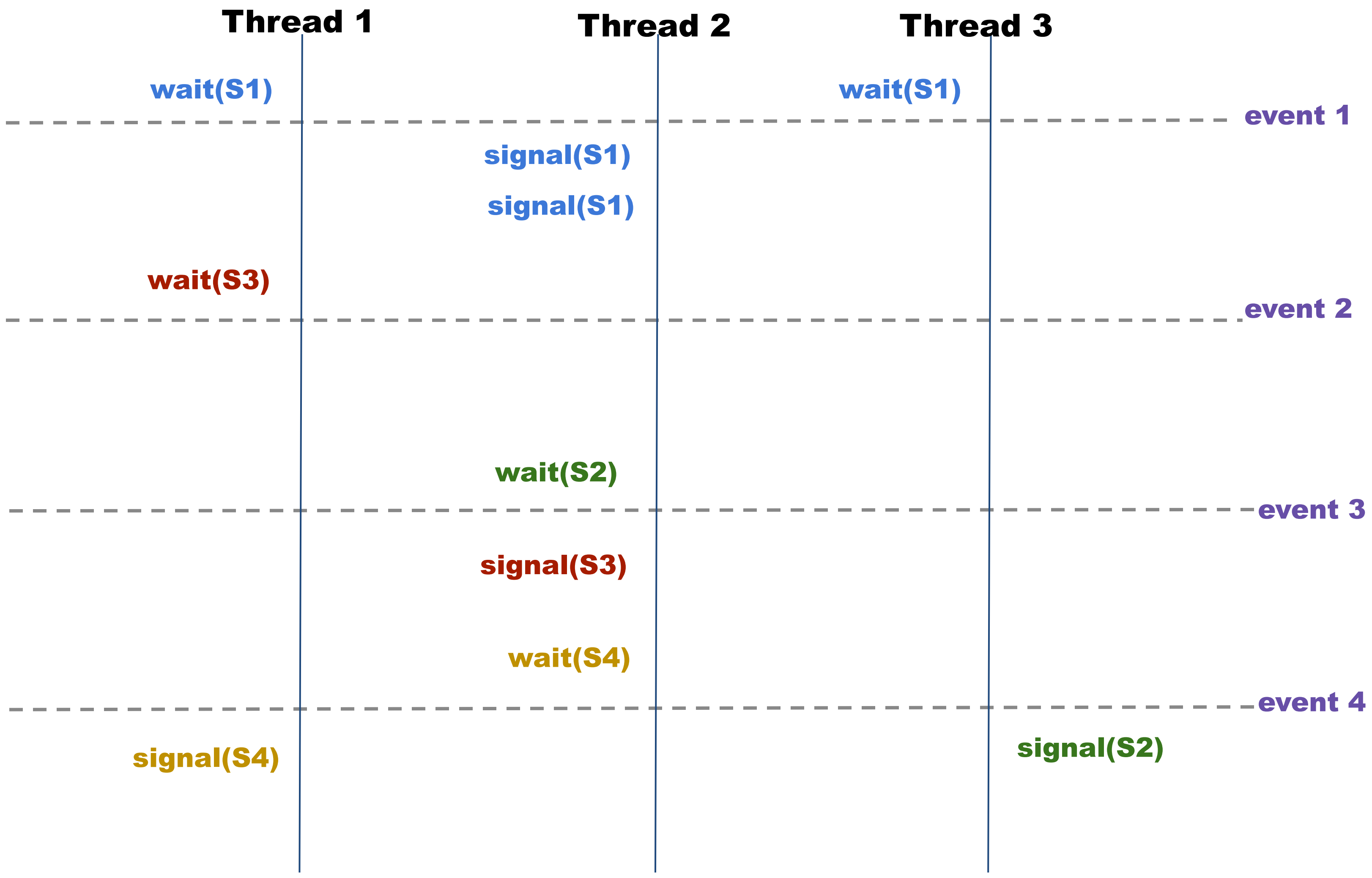
Mutexes, Semaphores, Monitors and Condition Variables (Chapters 5,6+7)

- How does a mutex differ from a semaphore?
- What does wait() and signal() do in a semaphore context?
- Why do monitors simplify synchronization compared to semaphores?
- What is a condition variable used for inside a monitor?
- Can semaphores cause deadlock? When?

Deadlock - Conditions, Detection, and Avoidance (Chapters 7+8)

- What are the four necessary conditions for deadlock?
- How does a resource-allocation graph help us detect deadlocks?
- What’s the difference between avoidance (Banker’s algorithm) and prevention?
- Is it ever acceptable to let deadlock occur? (Why might Linux do this?)
- How can ordering resource requests avoid circular wait?

Semaphore Question



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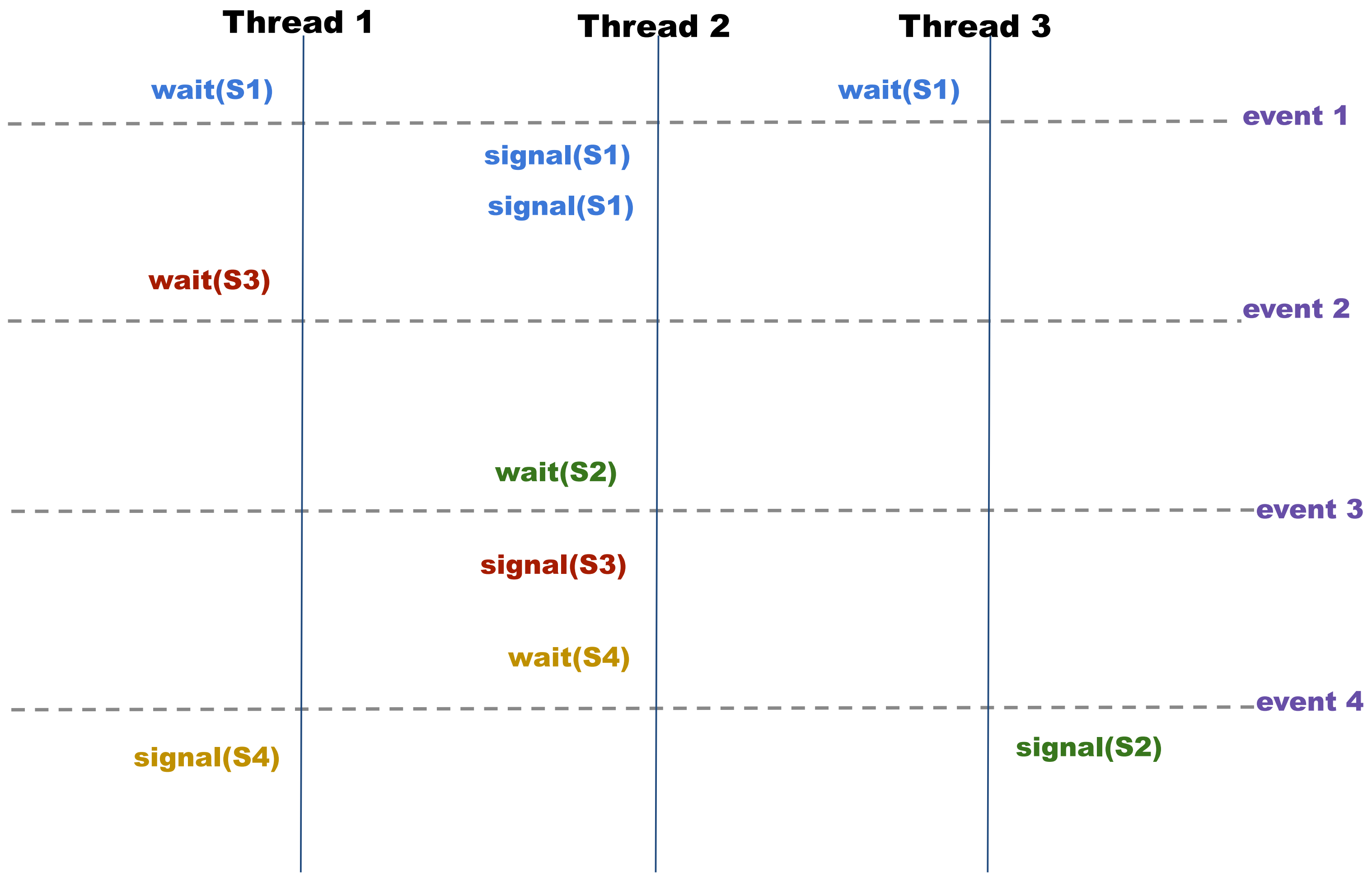

In what order order do these threads execute each event?

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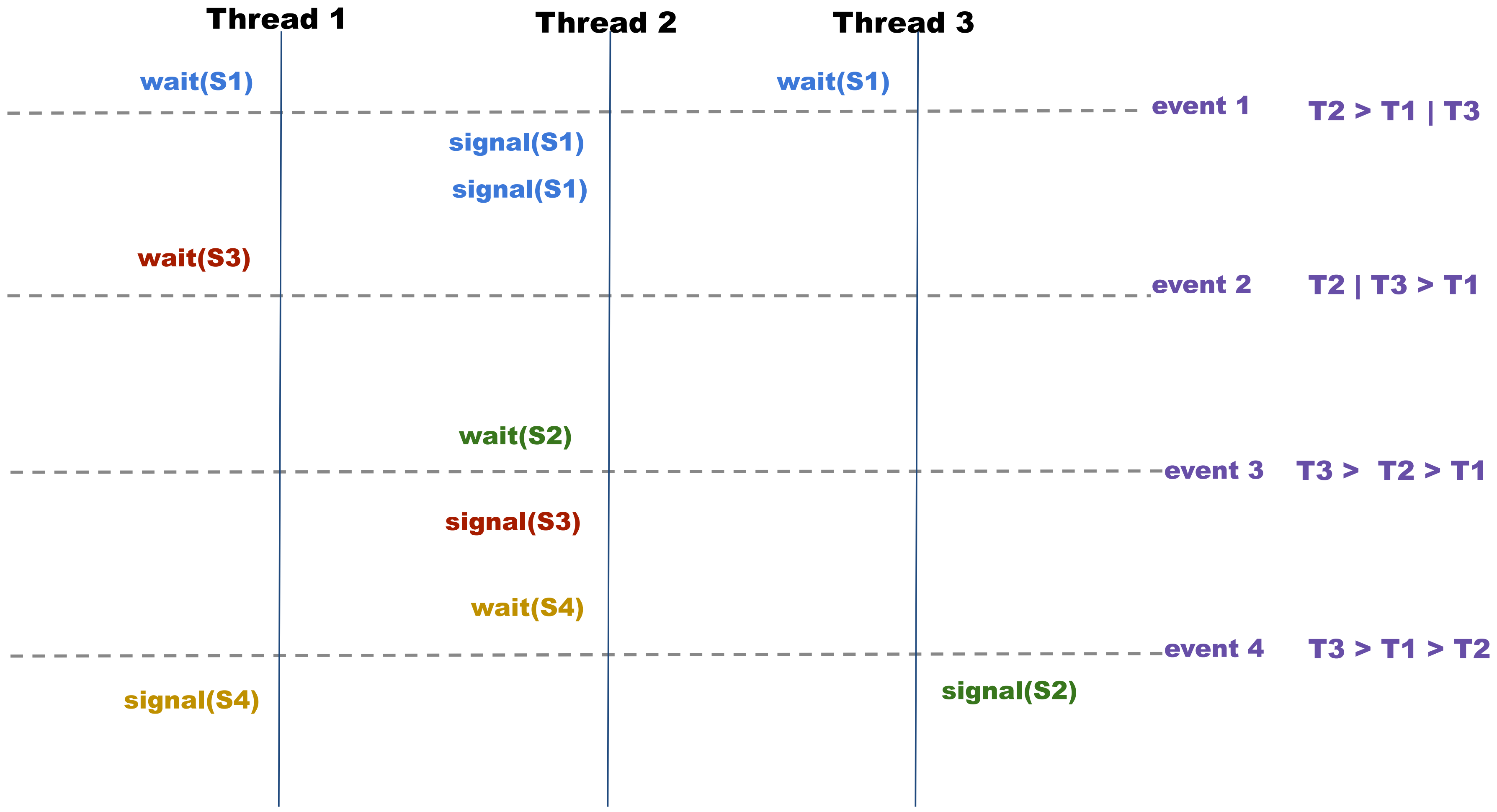
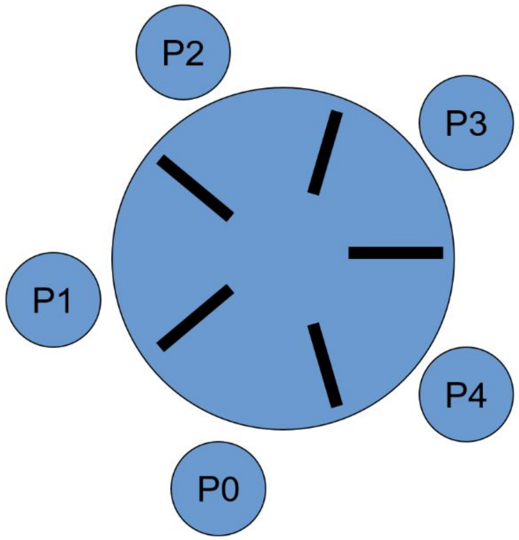


Philosophers Dining Problem



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   status state[5];
   condition self[5];

   Pickup(int i) {
      state[i] = hungry;
      test(i);
      if(state[i]!=eating)
         self[i].wait;
   }

   test(int i) {
      if (state[(i+1)%5] != eating &&
         state[(i-1)%5] != eating &&
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         state[i] = eating;
         self[i].signal();
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   Putdown(int i) {
         state[i] = thinking;
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   }

   init() {
      for i = 0 to 4
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   }
} // end of monitor
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2 - Assume the philosopher from your answer in part a is now eating. Next, P1 will arrive and set its state to hungry, is P1 able to begin eating?

3 - Now P3 will finish eating, who will be next to eat?

4 - Assume P0 is gluttonous and never stops eating, identify any issues with our table

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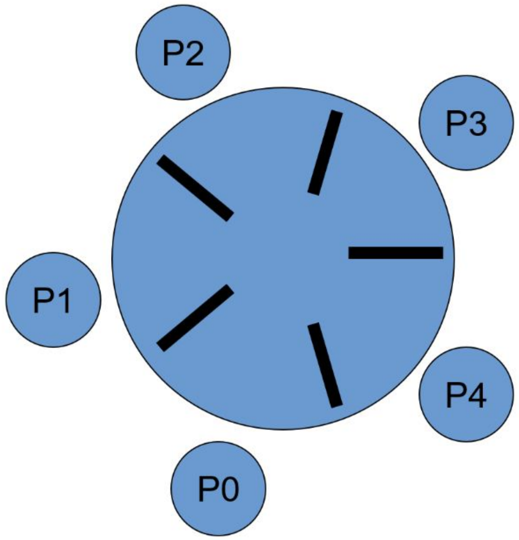

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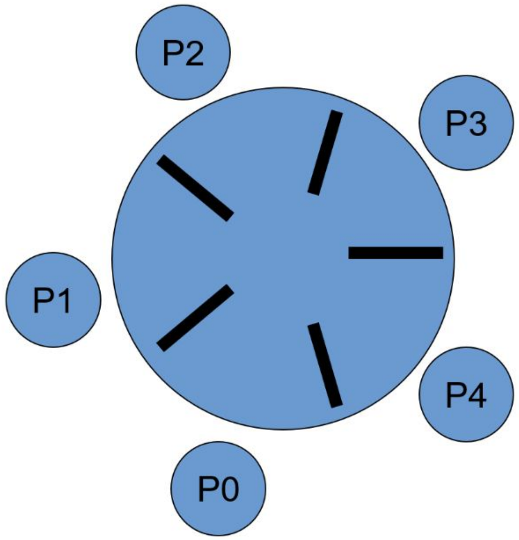

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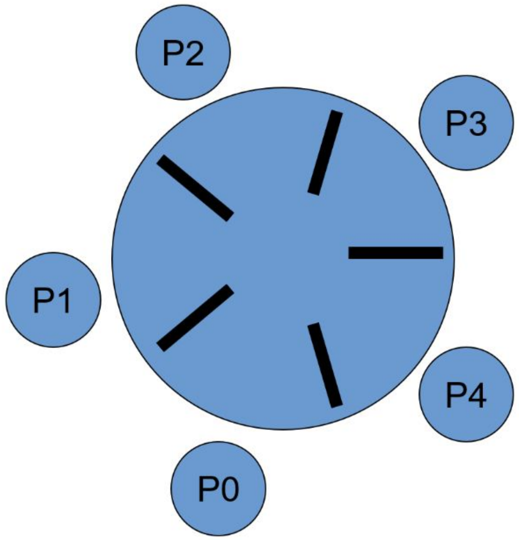

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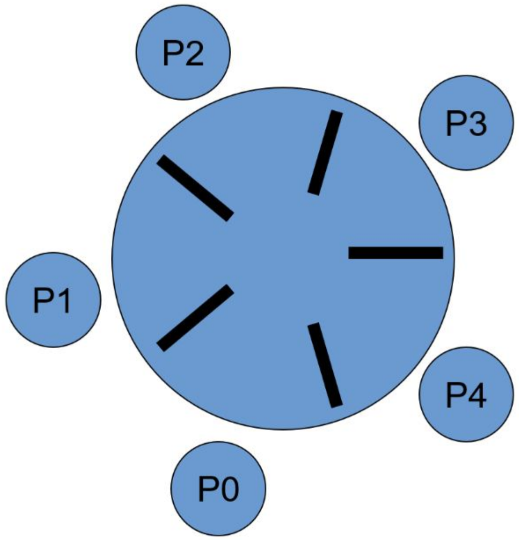

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Philosophers are starving

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But with N=4:

3 + 3 + 3 + 4 == NO DEADLOCK